



GREEN BARLEY AS AN INGREDIENT IN PASTA: ANTIOXIDANT ACTIVITY AND SENSORY CHARACTERISTICS EVALUATION

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Summary: The aims of the present study was to determine antioxidant activity, sensory properties as well as total polyphenol, flavonoid and chlorophyll content of raw and cooked pasta enriched by 1%, 3% and 5% addition of green barley powder. Results of antioxidant activity showed that increase of green barley addition increase antioxidant activity of pasta. The values in raw pasta obtained by DPPH ranged from 1.17 (control) to 1.81 (5% addition) mg TEAC/g DM, after cooking values ranged from 0.82 (control) to 1.59 (5% addition) mg TEAC/g DM. Similar tendency was signed by molybdenum reducing antioxidant power method. In enriched pasta was also found higher content of total polyphenol (0.19 in control raw sample and 1.81 mg GAE/g DM in pasta with 5 % of green barley addition; values of cooked pasta ranged from 0.10 in control sample to 0.73 mg GAE/g DM in pasta with 5 % of green barley addition) as well as total flavonoid content (results of raw pasta were from 0.00 in control sample to 0.41 mg QE/g DM in pasta with 5% of green barley addition; values of cooked pasta were from 0.00 in control sample to 0.29 mg QE/g DM in variant with 5% green barley). Green barley also enriched pasta for chlorophyll with the best results in 5% addition. From prepared variants of enriched pasta the best overall acceptability was sign in 3% of green barley addition. Pastas enriched with plant-derived bioactive compounds such as green barley may confer health benefits to consumers.

Key words: enriched pasta, polyphenols, flavonoids, chlorophyll

INTRODUCTION

Nowadays, a growing demand for healthy food, such as products enriched with plant bioactive compounds and low energy, has been observed. Cereal-based foods are of primarily importance in human nutrition; since they represent 30-70% of daily energy intake (WHO/FAO, 2003). Pasta is a widely consumed food because of its low cost, easy preparation, and long shelf life. High quality pasta is manufactured using durum wheat semolina because of its very good cooking quality and high consumer acceptance (Biernacka et al., 2017). However in Slovakia is more traditional prepare pasta from *Triticum aestivum* L. flour type T650 due to the price and also agro technical causes, because *Triticum durum* L. is grown in Slovakia only in small amount. Pasta may represent an excellent model food vehicle for the addition of specific nutrients through incorporation of various products (eggs, milk powder, vegetables, fiber, medicinal herbs, and so on) in a targeted food product to enhance nutritional quality, improve health condition and reduce the risk of diseases (Tazart et al., 2016). Barley (*Hordeum vulgare* L.) leaf is the one of the green grasses, and is a well-known component of green-colored powders, named "Zelený jačmeň" in Slovakia and "Aojiru" in Japan. Because of the greater nutritional value, the leaves of barley are beneficial to human health when harvested at a young age (usually within 2 weeks after seeding) (Kim et al., 2017). Young green barley leaves are a good natural source of vitamins and minerals, and their juice is widely consumed as a functional food for health reasons mainly in Japan, but this product starts be very popular also in Europe (Yamaura et al., 2015).

The main aim of present study was to prepare pasta enriched with green barley powder (1, 3 and 5%) and subsequently determine sensory and biological activity of raw and cooked pasta.

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MATERIAL AND METHODS

Material. Green barley powder (100% from bio production Vegafit, Germany; composition per 100 g: proteins – 29 g, fat – 5 g, sugars – 3.4 g, dietary fiber – 39 g) was purchased from local market as well as ingredients for preparing of pasta (flour T-650, eggs, salt). All chemicals used in this work were of analytical grade and purchased from Sigma-Aldrich (USA) and CentralChem (SK).

Pasta making process. Pasta samples were produced using an extruder (Gina, Italy) for the production of the extruded pasta. Here, 500 g flour type T-650 were mixed with green barley powder (1, 3 and 5%), one egg (60 g), salt (7 g) and tap water in a rotary-shaft mixer at 25° C for 20 min, to obtain dough with 30% moisture content. A screw (length, 30 cm; diameter, 5.5 cm) that ended with a bronze die (hole diameter, 1.70 mm) was used to extrude the dough into a elbows shape. The screw speed was 50 rpm. The extrusion pressure was approximately 3.4 bar, and the temperature of the pasta after the extrusion was 27 C to 28°C. Extruded pasta was dry in drying chamber (8 hours at 40° C) to final moisture content approximately 12.5%. Before the analyzing pasta was homogenized to particle size 0.5 mm.

Extract preparation. 0.25 g of sample was extracted with 20 mL of 80% ethanol for 24 hours (25° C). After centrifugation at 4000 g (Rotofix 32 A, Hettich, Germany) for 10 min, the supernatant was used for measurement (antioxidant activity, polyphenols, flavonoids). Extraction was carried out in triplicate.

For chlorophyll determination 1 g of sample and 80% acetone were added into the mortar and the sample was completely broken into pieces (0.5 mm). The obtained extract was eluted with 80% acetone and filtered into 50 mL flasks through a common filter paper (Whatman 1; 11µm).

Radical scavenging activity. Radical scavenging activity of samples was measured using 2,2-diphenyl-1-picrylhydrazyl (DPPH) (Yen and Chen, 1995). Absorbance of the reaction mixture was determined using the spectrophotometer Jenway (6405 UV/Vis, England) at 515 nm. Trolox (6-hydroxy-2,5,7,8-tetramethylchroman-2-carboxylic acid) was used as the standard and the results were expressed in mg/g Trolox equivalents.

Molybdenum reducing antioxidant power method. Molybdenum reducing antioxidant power method of samples was measured according Prieto et al., (1999) method with a slight modification. Absorbance of the reaction mixture was determined using the spectrophotometer Jenway (6405 UV/Vis, England) at 700 nm. Trolox (6-hydroxy-2,5,7,8-tetramethylchroman-2-carboxylic acid) was used as the standard and the results were expressed in mg/g Trolox equivalents.

Total polyphenol content. Total polyphenol content of extracts was measured by the method of Singleton and Rossi, (1965) using Folin-Ciocalteu reagent. Absorbance of the reaction mixture was determined using the spectrophotometer Jenway (6405 UV/Vis, England) at 700 nm. Gallic acid was used as the standard and the results were expressed in mg/g gallic acid equivalents.

Total flavonoid content. Total flavonoids were determined using the modified method of Lamaison and Carnat (Quettier – Deleu et al., 2000). Absorbance of the reaction mixture was determined using the spectrophotometer Jenway (6405 UV/Vis, England) at 405 nm. Quercetin was used as the standard and the results were expressed in µg/g quercetin equivalents.

Total chlorophyll content. Total chlorophyll content was determined spectrophotometrically according to Lichtenthaler a Wellbum, (1983) method. Absorbance of the reaction mixture was determined using the spectrophotometer Jenway (6405 UV/Vis, England) at 649 and 664.5 nm. Results were expressed in mg/g.

Sensory evaluation. The sensory evaluation was carried out by 20 judges in the age group 20-60 years comprising of students and consumers. A nine-point hedonic scale was used to evaluate smell, green barley smell presence, green barley smell intensity, foreign smell, taste, green barley taste presence, green barley taste intensity, aftertaste, overall acceptability.

Statistical analysis. The basic statistical analyzes were realized in sas programming packages (THE SAS SYSTEM V 9.2.). Correlation coefficients were calculated by CORR analysis (SAS, 2009).

RESULTS AND DISCUSSION

Radical scavenging activity. The highest activity (Tab. 1) in raw enriched pasta was detected in pasta with 5% green barley addition. Results were compared with control sample without addition, in which was found the lowest activity. Prepared raw pasta was cooked and after this process was also detected antioxidant activity. Antioxidant activity of pasta after boiling process decreased, which was no surprising because high temperature decrease amount

of biologically active compounds, but after boiling process enriched pasta had better activity with compare to control sample, when activity was not detected. Boroski et al., (2011) determined antioxidant activity of pasta enriched by oregano and carrot leaf and found better activity with compared to control without addition.

Table 1. Radical scavenging activity of prepared pasta (dry matter)

Pasta sample	DPPH [mg TEAC/g]	DPPH [mg TEAC/g]
	Raw pasta	Cooked pasta
Control sample	1.17 ±0.47	0.83 ±0.06
1% green barley addition	1.51 ±0.07	1.51 ±0.07
3% green barley addition	1.52 ±0.07	1.40 ±0.03
5% green barley addition	1.81 ±0.12	1.59 ±0.04

TEAC – Trolox equivalent antioxidant capacity; ±standard deviation

Molybdenum reducing antioxidant power method. Similar tendency like using radical scavenging activity was observed using molybdenum reducing antioxidant power method (Tab. 2). Control sample without enrichment showed the lowest activity. Increasing addition of green barley powder increased antioxidant activity measured with this method, with the best values in 5% green barley addition pasta – raw (21.96 mg TEAC/g) and cooked (12.64 mg TEAC/g). Higher antioxidant activity of enriched pasta is due to antioxidant from green barley. Pauličková et al., (2006) reported that green barley leaves contains significant quantities of calcium, copper, iron, magnesium, potassium, zinc, β -carotene, folate, pantothenic acid, vitamins B₁, B₂, B₆, C, and E, superoxide dismutase, catalase, carotenoids and chlorophyll. Seczyk et al., (2015) evaluated pasta with addition of parsley leaves powder in amount 1% and 4%. Their results showed that parsley similarly like green barley in our study increased the antioxidant activity (FRAP method) of pasta with the best results in 4% parsley addition.

Table 2. Molybdenum reducing antioxidant power (MRAP) of prepared pasta (dry matter)

Pasta sample	MRAP [mg TEAC/g]	MRAP [mg TEAC/g]
	Raw pasta	Cooked pasta
Control sample	13.34 ±1.16	5.02 ±0.93
1% green barley addition	13.69 ±0.37	9.13 ±0.31
3% green barley addition	14.62 ±0.68	11.71 ±1.29
5% green barley addition	21.96 ±1.01	12.64 ±1.41

TEAC – Trolox equivalent antioxidant capacity; ±standard deviation

Total polyphenol content. Polyphenols are ubiquitous secondary metabolites in plants. They are known to have antioxidant activity and it is likely that the activity of these extracts is due to these compounds (Tepe et al., 2006). Total polyphenol content in raw and cooked pasta was the highest in pasta with 5% green barley addition. The lowest content (Tab. 3) was found in control sample. After cooked process content was decreased similarly like antioxidant activity, but enriched pasta showed better activity with control sample, in which these compounds were only in small amount. The best value in 5% green barley pasta is probably due to higher amount of phenolic antioxidants such as phenolic acid derivatives, proanthocyanidins, quinones, and flavonoids. Statistically strong correlation ($p \leq 0.05$) was observed in our study between total polyphenol content and DPPH method ($\rho = 0.914$).

Total flavonoid content. Flavonoids are regarded as one of the most widespread groups of natural constituents found in plants (Suhartono et al., 2012). Total flavonoid content (Tab.3) in enriched pasta ranged from 0.05 to 0.41, with the best results in 5% green barley addition pasta. In control raw pasta was no detected presence of these compounds. After cooking the amount of flavonoids decrease rapidly (pasta with 1% and 5% of green barley addition). Role of flavonoids in human health is supported by the ability of the flavonoids to induce human protective enzyme systems, and by a number of epidemiological studies suggesting protective effects against cardiovascular diseases, cancers, and other age-related diseases (Yao et al., 2004). Pasta enriched with green barley can effectively increase amount of flavonoids in human diet. Kamiyama and Shibamoto, (2012) reported that green barley leaves contain saponarin, flavonoid possesses potent antioxidant activities, which are determined by its inhibition of malonaldehyde formation from various lipids oxidized by UV light or Fenton's reagent.

Total chlorophyll content. Chlorophyll is very important natural colorant which has many health benefits such as anti-inflammatory, antiseptic and antioxidant. Pasta prepared with green barley addition (Tab. 3) showed not only

better antioxidant activity but enriched pasta also for chlorophyll with compare to control sample without addition. The higher values of this natural colorant was detected in 5% green barley pasta – raw and cooked. Chlorophyll from green barley had positive influence also for pasta color, which consumers evaluated in sensory evaluation positively, because nowadays we can observe big interest about foods prepare with natural colorants. Statistically strong correlation ($p \leq 0.05$) was observed in our study between molybdenum reducing antioxidant power method and total chlorophyll content ($\rho = 0.841$).

Table 3. Total polyphenol, flavonoid and chlorophyll content in prepared pasta (dry matter)

Sample	Total polyphenol [mg GAE/g]	Total flavonoid [µg QE/g]	Total chlorophyll [mg/g]
Control pasta raw	0.19 ±0.01	-	-
Control pasta cooked	0.11 ±0.02	-	-
1% green barley pasta raw	0.47 ±0.02	0.05 ±0.001	4.29 ±0.25
1% green barley pasta cooked	0.41 ±0.01	0.01±0.001	0.61 ±0.01
3% green barley pasta raw	0.61 ±0.02	0.19 ±0.02	9.48 ±0.01
3% green barley pasta cooked	0.49 ±0.01	0.16 ±0.01	0.64 ±0.01
5% green barley pasta raw	1.09 ±0.01	0.41 ±0.03	10.54 ±0.01
5% green barley pasta cooked	0.73 ±0.02	0.29 ±0.02	0.71 ±0.03

GAE– gallic acid equivalent; QE – quercetin equivalent ±standard deviation

Sensory evaluation. Judges evaluated all prepared pasta regarding control sample overall as good. From 1%, 3% and 5% pasta enriched with green barley powder (Fig. 1) was the best evaluated variant with 1%, which was attractive for consumer from taste, smell and overall acceptability point of view. 3% addition was also evaluated well, but many judges sign that in this variant felt unpleasant grassy aftertaste, similarly like in 5% variant in which also judges unpleasant grassy aftertaste and smell. Biological activity was best in 5% green barley pasta, but for food industry we recommend according to our results maximal percentage of addition 3%, because higher percentage of addition unpleasant influence smell and aftertaste. Generally enriched pasta with green barley powder increase sensory properties of pasta mainly taste and color, which effective increase attractively of these products for consumers.

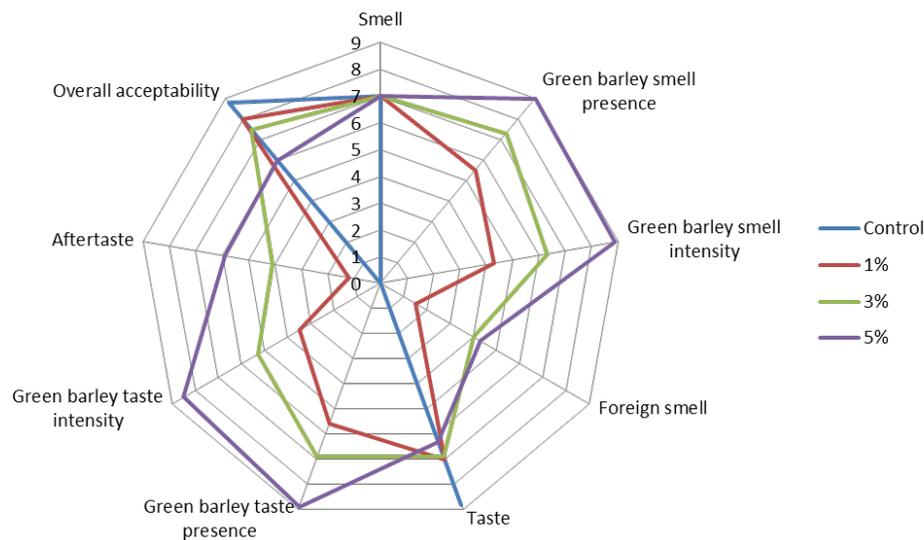


Figure 1. Sensory evaluation of prepared pasta (1%, 3%, 5% - % of green barley addition)

CONCLUSION

Green barley powder from young leaves being rich in phytochemicals and incorporation of these into pasta products will add health benefits. As consumption of pasta is becoming popular worldwide, this kind of pasta will supply essential nutrition as well as health benefits. Polyphenols, flavonoids and chlorophyll content in developed green barley based pasta were significantly higher than in control pasta. The developed functional pasta showed increase in phenolic content and antioxidant activity, but this content decreased slightly after cooking. Generally biological activity was best in 5% green barley pasta, but for food industry we recommend according to our results maximal percentage of addition 3%, because higher percentage of addition unpleasant influence smell and aftertaste. Thus it could be concluded that good quality nutrient rich pasta can be prepared with green barley addition.

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